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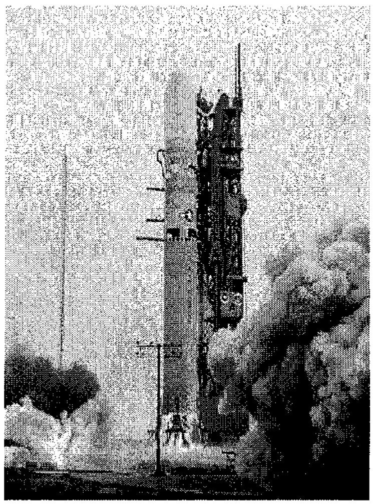
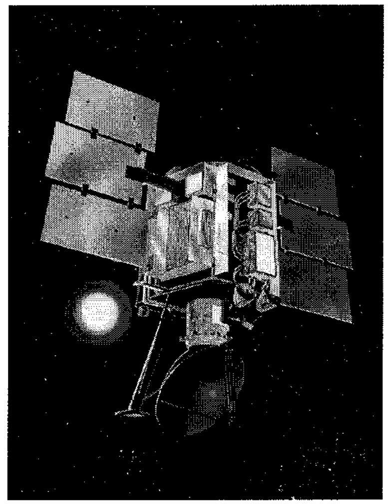
New Applications on Land and Ocean using SeaWinds Scatterometer on QuikSCAT





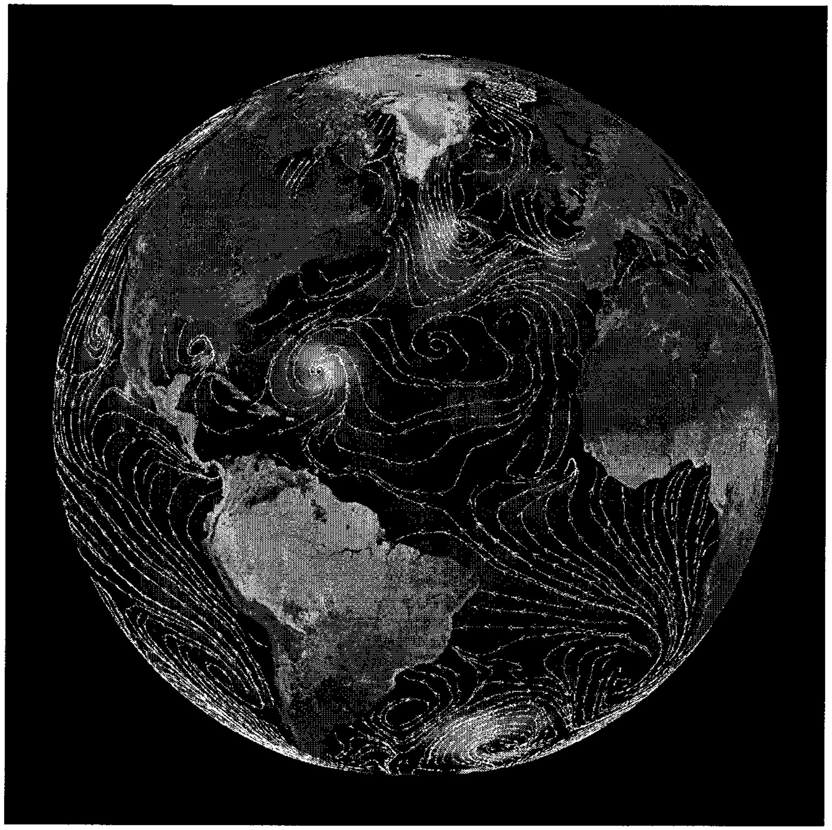
S. V. Nghiem, W. Y. Tsai, and J. J. van Zyl

Scatterometer Applications

Operated at Ku-band (13.4 GHz)

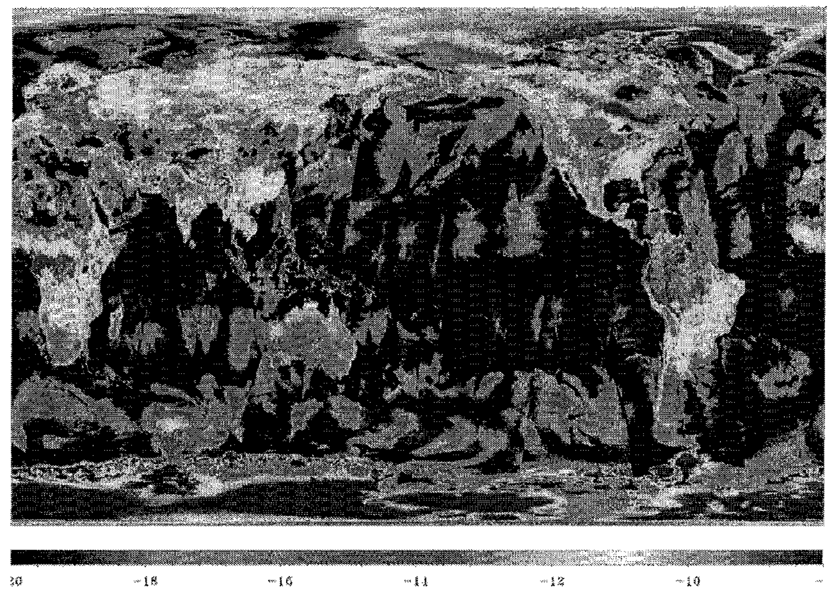
Global Ocean Vector Winds

for Ocean Science & Operational Applications



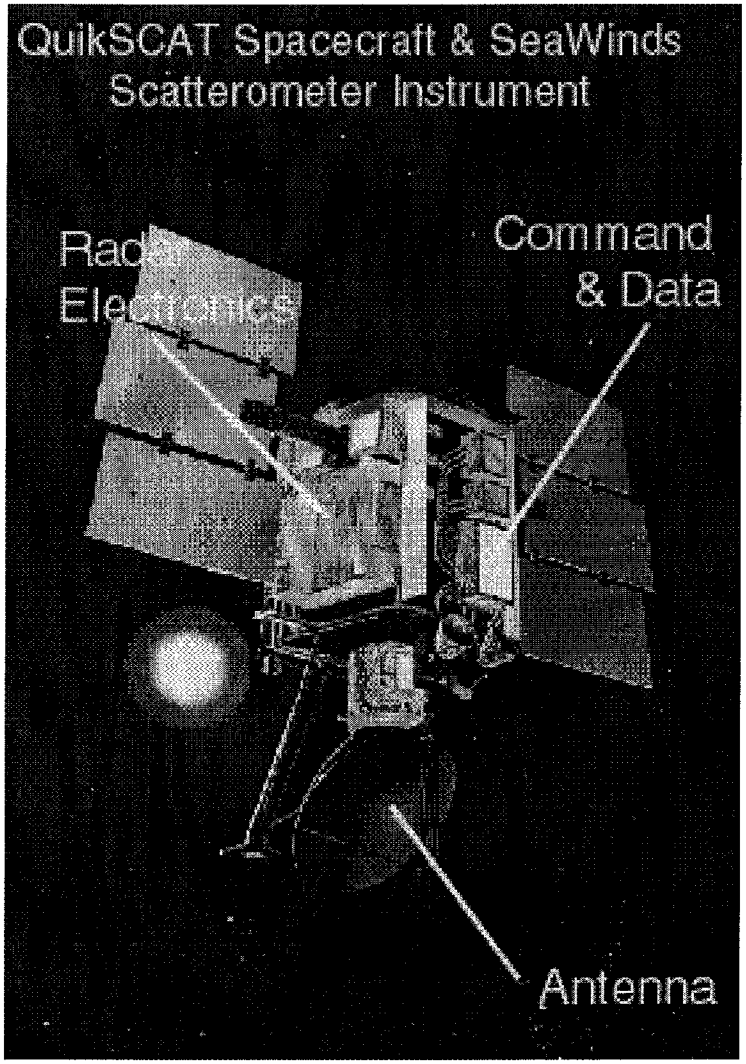
Global Sigma-0's

for Studying the Land and Ice Processes



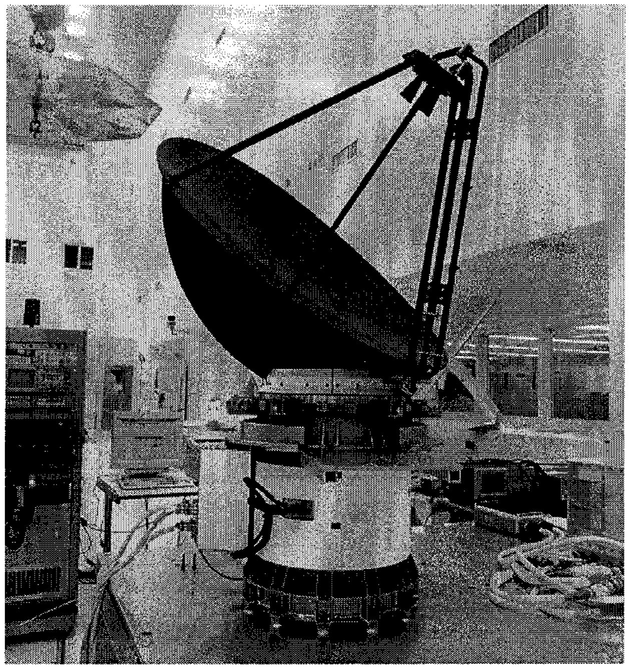
QuikSCAT Backscatter σ_{vv} (dB) : 2000.03.16–2000.03.17

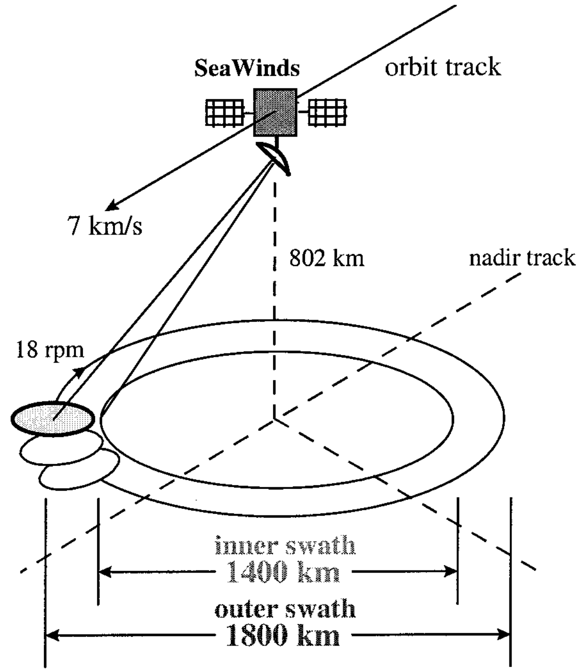
SeaWinds on QuikSCAT Mission



- Mission initiated after loss of NSCAT on ADEOS-I in 6/97 (due to ADEOS-I failure).
- First NASA rapid deployment mission; Ready for launch within 11 months of project start date.
- Launched from VAFB using Titan II on June 19, 1999.
- Operated smoothly in the past 15 months
- Approval for extended mission through September 2002 (due to SeaWinds/ADEOS-II launch delay).

SeaWinds System Design





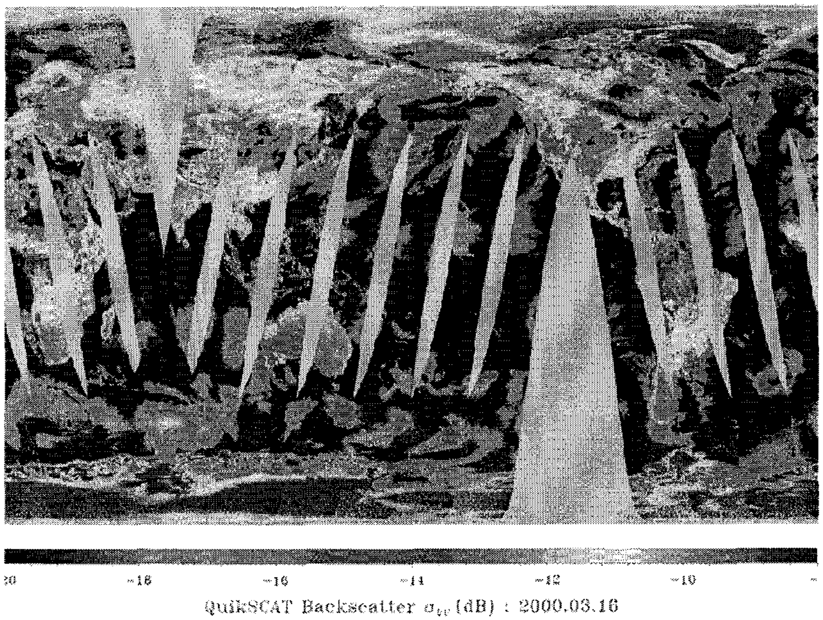
- Ku-band radar (13.4 GHz) with range compression
- Conical spinning 1-meter dish antenna
- Two antenna beams at constant incidence angles:

    H-pol. at 46°   V-pol. at 54°

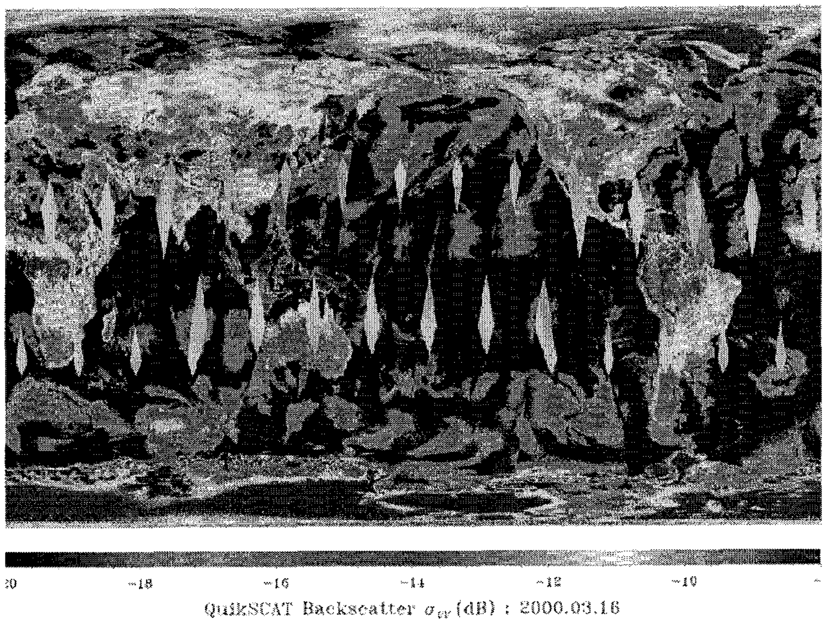
SeaWinds on QuikSCAT: Unique Characteristics

1. Very wide measurement swath (approx 1800 km)
   - 75% global coverage in 12 hours
   - 92% global coverage in one day
   - Twice daily coverage at higher latitudes (>40 deg)
2. Relatively high resolution
   - 7 x 25 km slice σ_0 resolution
   - 25 km wind-vector cell resolution (standard product)
3. Near simultaneous dual polarization σ_0 measurements with high radiometric accuracy
   - Relative σ_0 accuracy of about 0.2 dB
4. σ_0's are measured at constant incidence angles
   - Enables simple and accurate determination of land and ice geophysical parameters

QuikSCAT Global Coverage



75% of Earth in 12 hours



92% of Earth in 24 hours

Emerging Land and Ocean Applications

- Primary science products are ocean surface vector winds for ocean science and operational applications. Results were presented by Science Team members in various science conferences.

- We explore new science applications of the global σ_0 products. In the following, we will present the following innovative applications:

    - Global flood detection
    - Large scale soil moisture monitoring
    - Global snow cover monitoring
    - Greenland ice melt zone detection
    - Storm tracking with high resolution wind
    - Sea ice mapping and ice albedo transition timing

Global Flood Detection

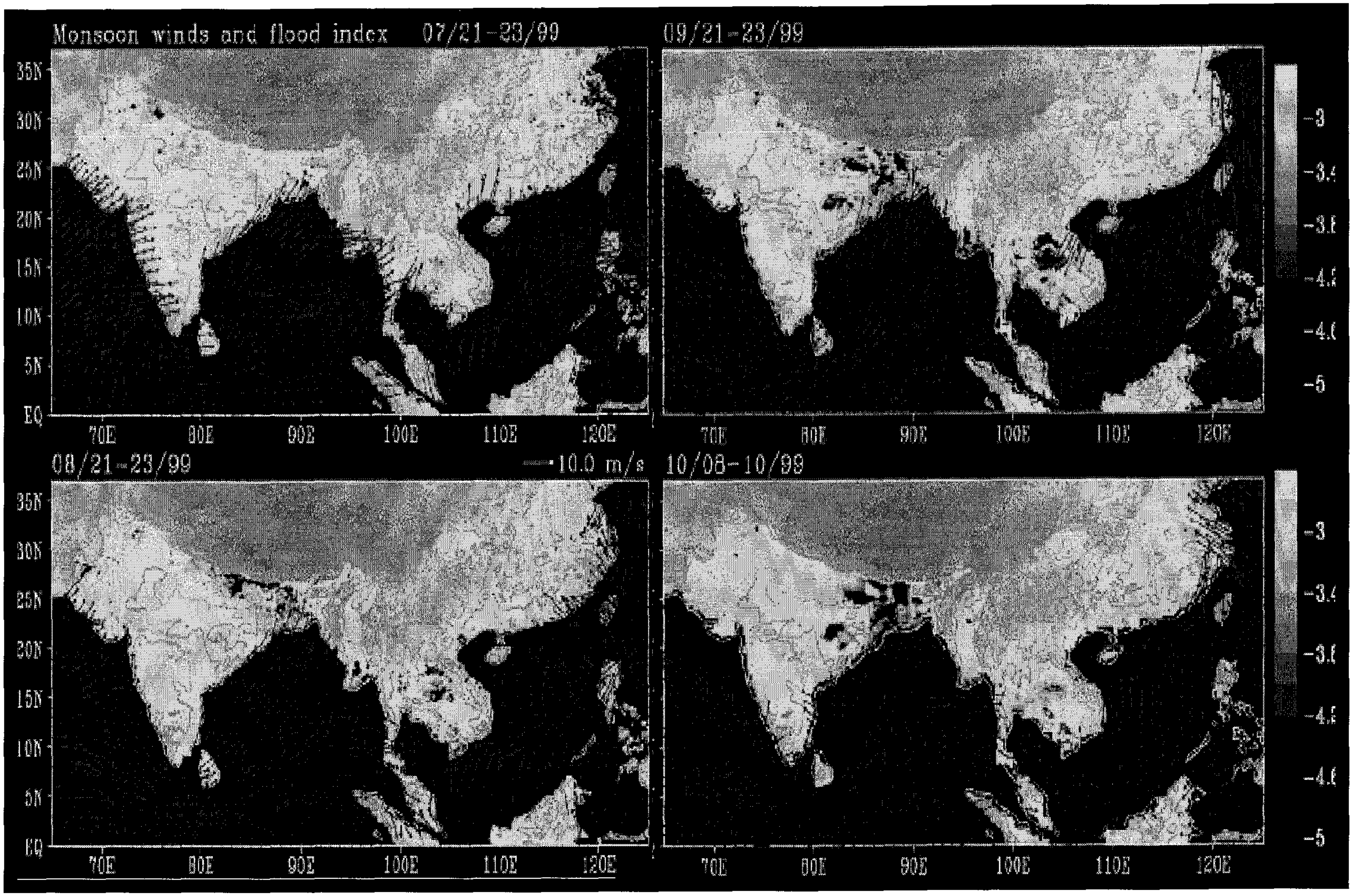
- Principle for flood detection:
  At a given incidence angle, backscatter over flooded cropland or urban area is higher for HH than VV

- For SeaWinds scatterometer on QuikSCAT:
  VV is at larger incidence angle compared to HH causing even large difference between HH & VV

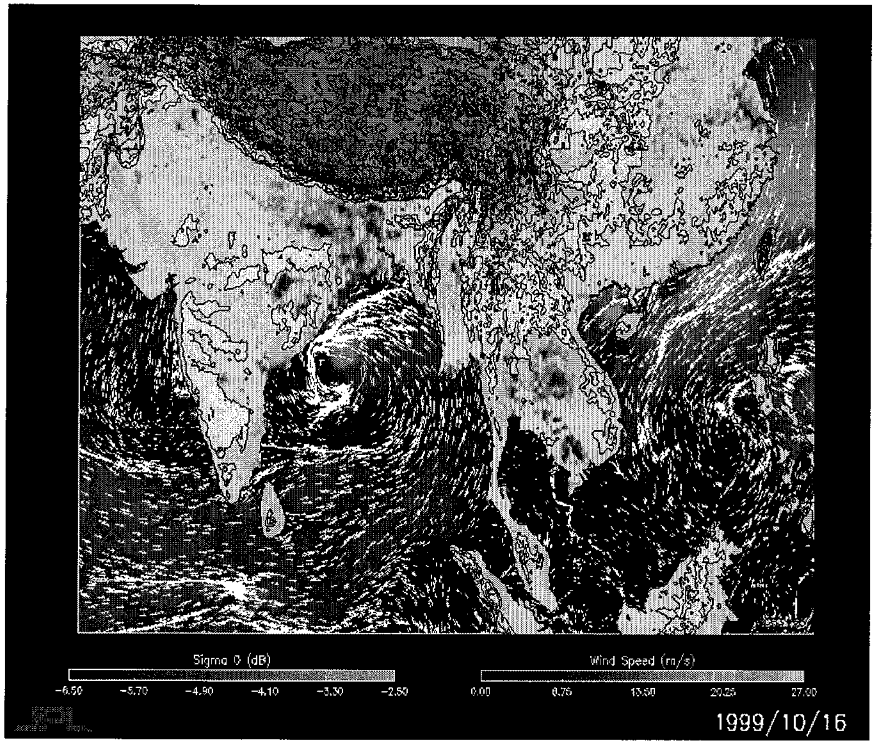
- To detect flooded areas, we use $\sigma_0(VV)/\sigma_0(HH)$ and a smaller value indicates more probability of flooding

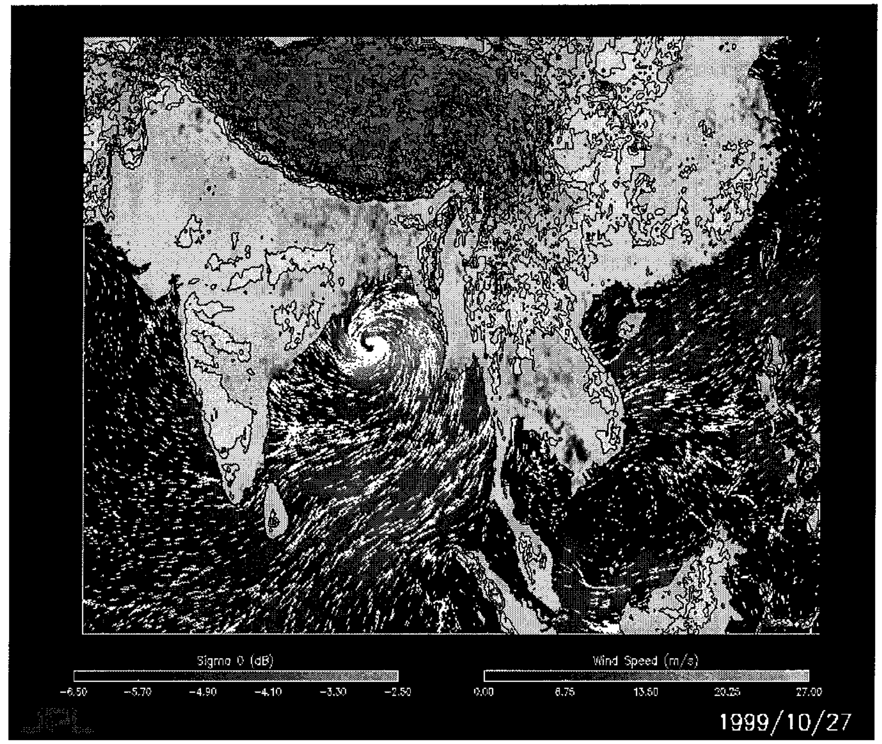
- Examples: Asian Monsoon flood detection

Asian Monsoon Floods



The Orissa Disaster





The 1999 Orissa Disaster: In middle of October, a super cyclone hit Orissa in western India causing severy flooding; another one hit Orissa again causing more destruction and damages. This disaster affected 15 million people.

Large Scale Soil Moisture Detection

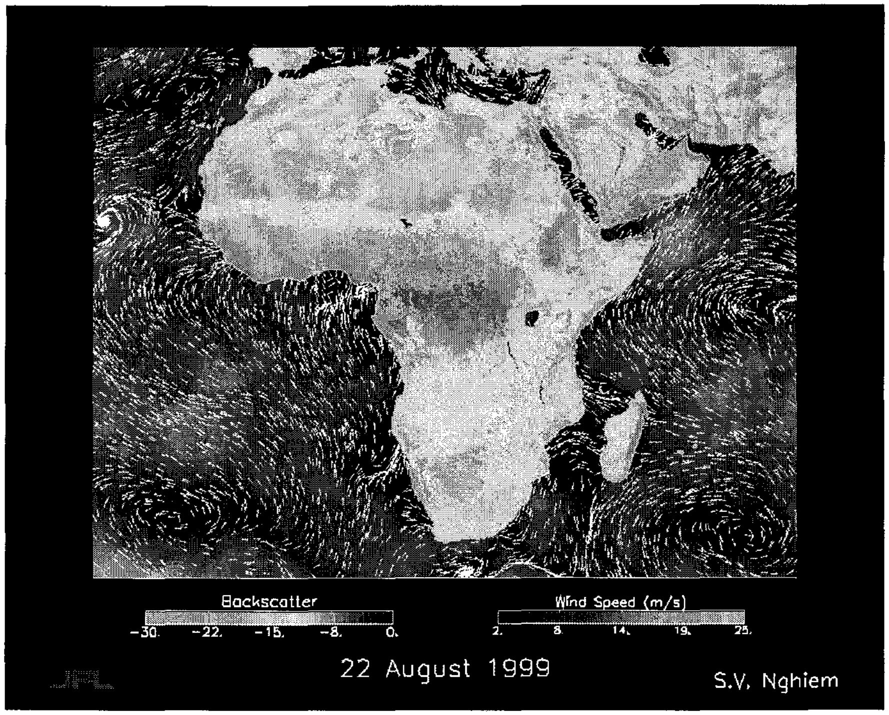
- QuikSCAT has very large swath, enabling the generation of high resolution (~ 13 km) global map once every two days, which are appropriate for weather envent time scale.

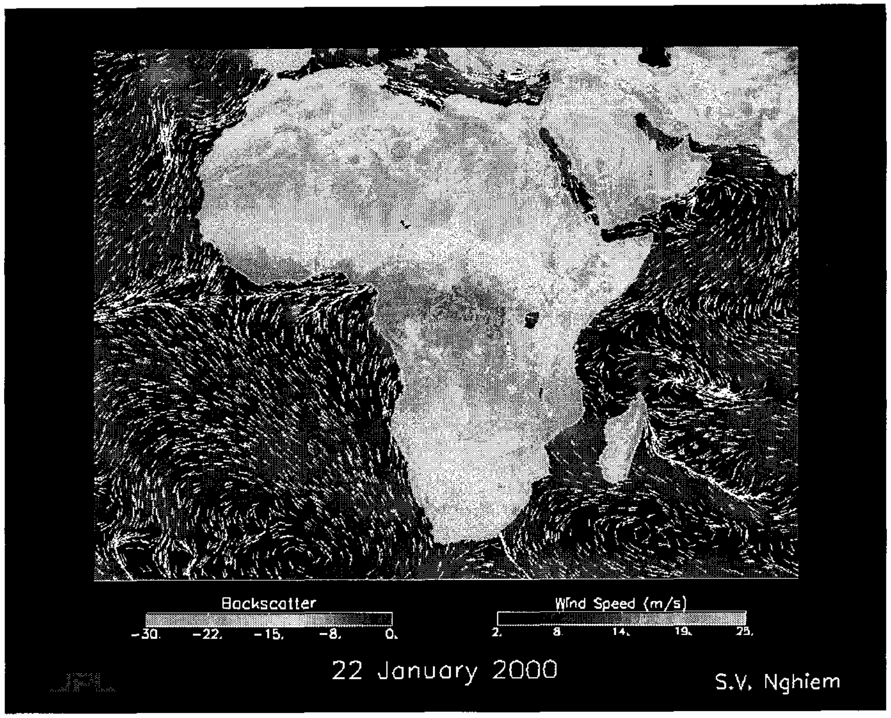
- Ku-band backscatter is sensitive to surface soil moisture, which increases the backscatter for wetter soil.

- Backscatter signature of temporal evolution of soil moisture shows short-term periods of high backscatter corresponding to rain events, and also seasonal variations correponding to hydrological/ecological changes.

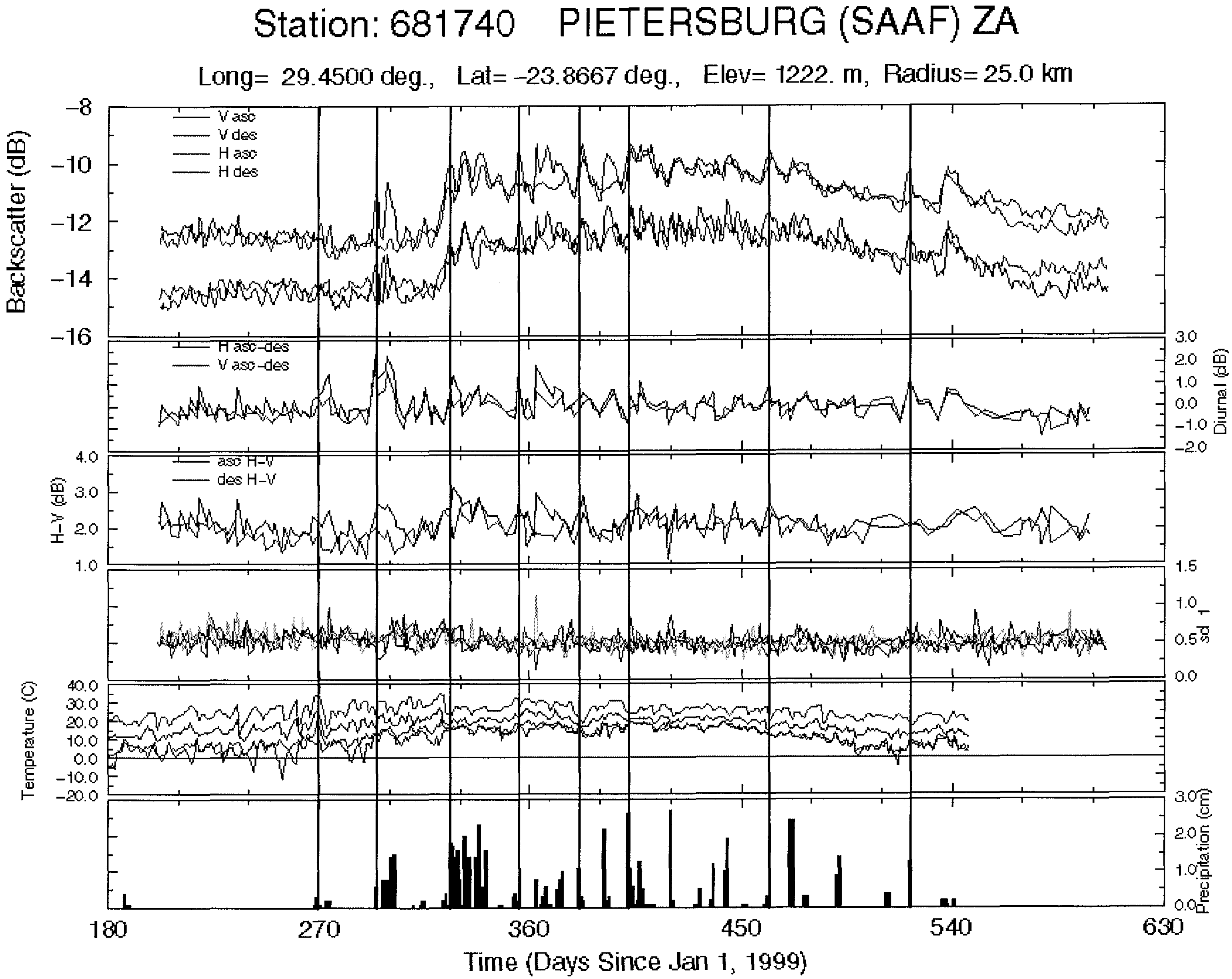
- Time series mapping over continental scale shows spatial distribution pattern of large-scale soil moisture.

African Soil Moisture Pattern





Seasonal moisture pattern (Aug-Jan): wetness was increasing in the west/central region, was unchanged in the east over Ethiopia, and was increasing in the south region. The changes correlate with the seasonal wind pattern over the annual period.



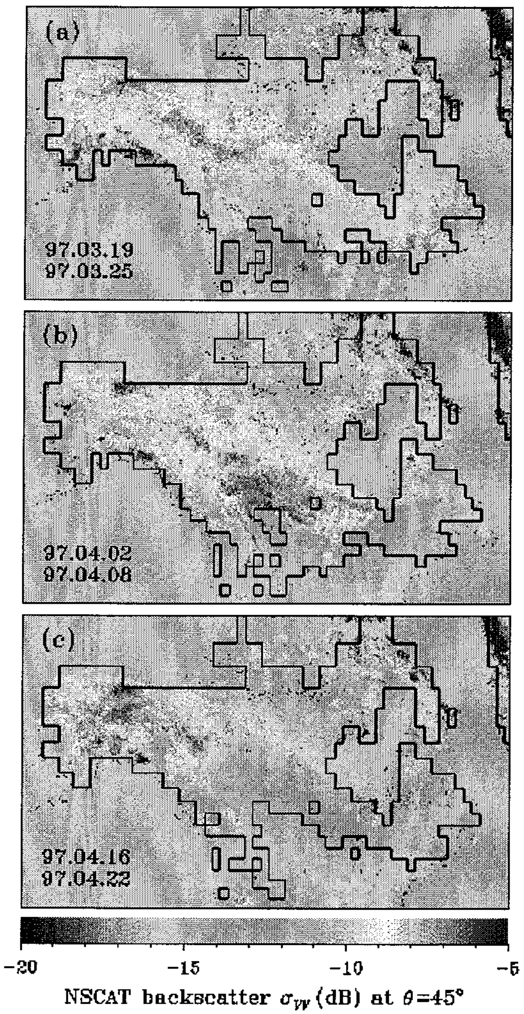
Station: 681740 PIETERSBURG (SAAF) ZA
Long= 29.4500 deg., Lat= -23.8667 deg., Elev= 1222. m, Radius= 25.0 km
Backscatter (dB)
V asc
V des
H asc
H des
H asc-des
V asc-des
Diurnal (dB)
asc H-V
des H-V
H-V (dB)
sd 1
Temperature (C)
Precipitation (cm)
Time (Days Since Jan 1, 1999)

Global Snow Detection

- QuikSCAT is appropriate for snow accumulation detection:
  - Strong Ku-band backscatter: Rayleigh scattering
  - Response of σ_0 to snow depth for most natural snow
  - Snow accumulation detection using change detection

- QSCAT measurements can be used for snow melt detection
  - Ku-band σ_0 is very sensitive to snow water content
  - QuikSCAT can have twice daily coverage for latitude higher than 40°
  - Melt region on snow cover is detected due to diurnal melt energy imbalance
  - Melt detection algorithm is also applied to delineate melt zones on the Greenland ice sheet.

Snow Events and the 1997 Flood of the Century

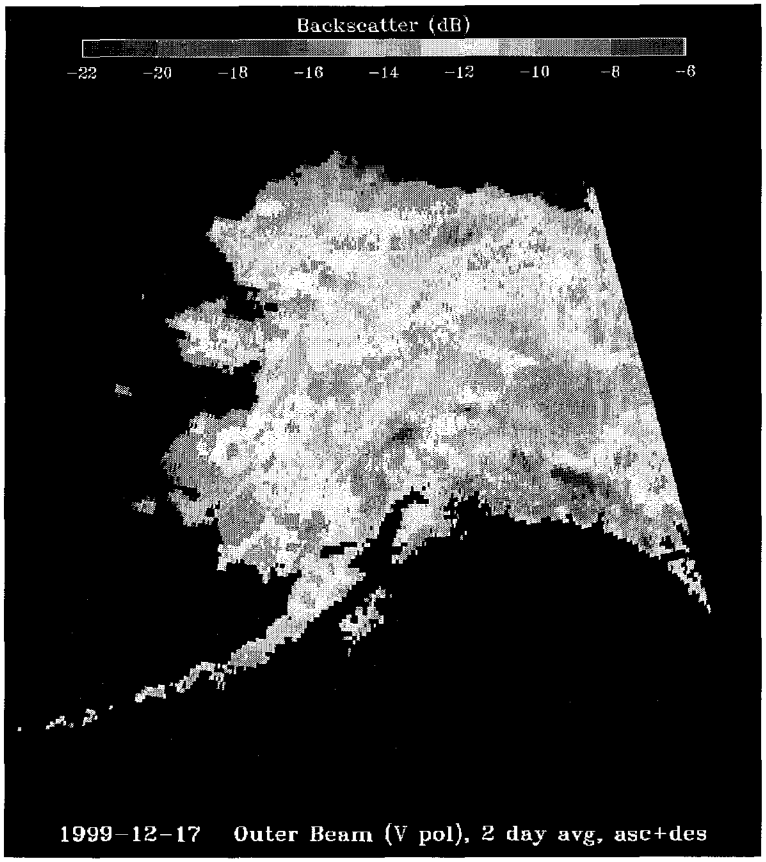


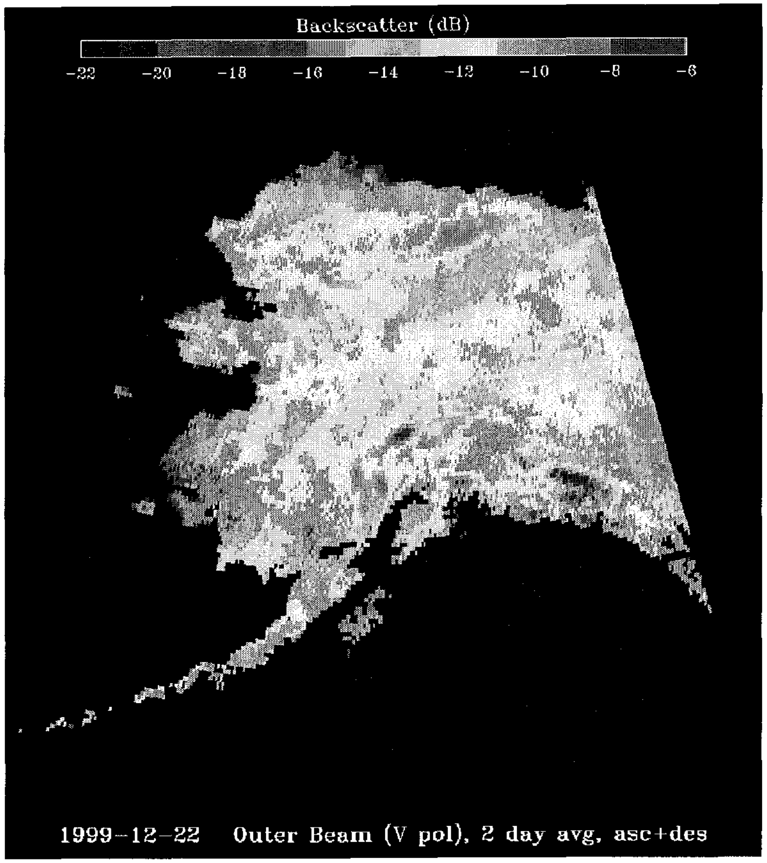
- **Late March:**
  Snow retreating north
- **Early April:**
  Snow blizzard
- **Later April**
  Fast smow melt

Red River broke 100-year record on 4/17/1997. Cost was several billion dollars.

(NSCAT data used for this case)

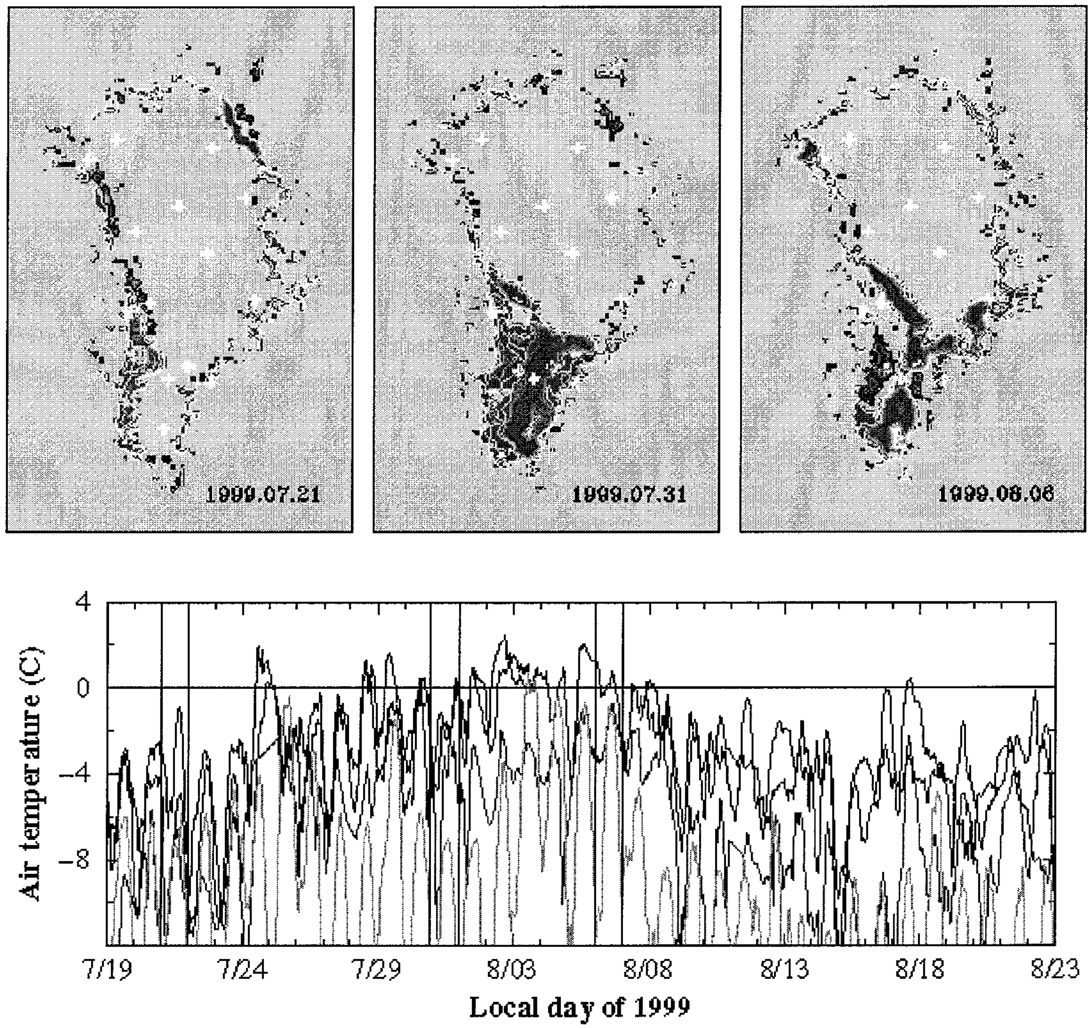
Alaska Winter Solstice Warming Anormaly





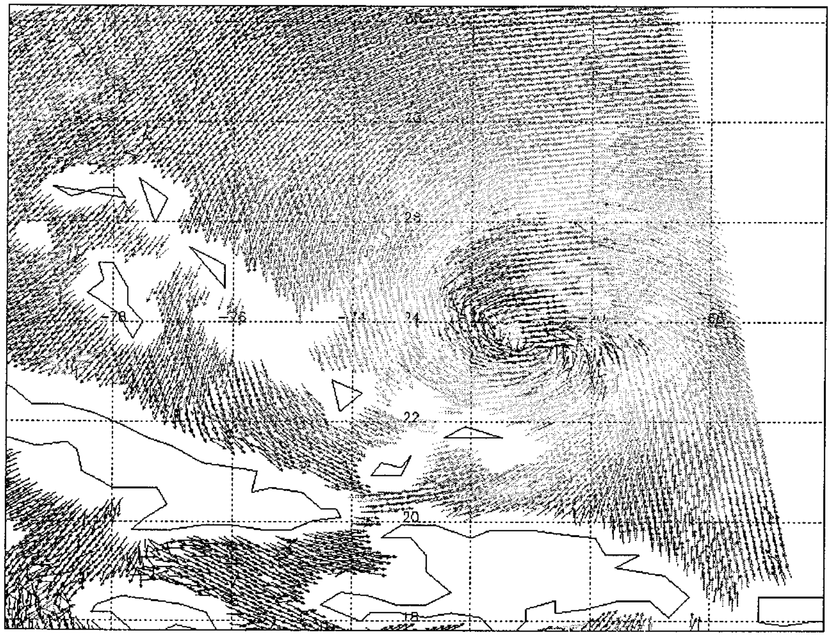
Left image shows extensive snow cover (yellow-red) by 12/17/99. An anomalous warming event is seen by the significant backscatter reduction on the 1999 winter solstice in the right image.

Greenland Ice Melt Zones



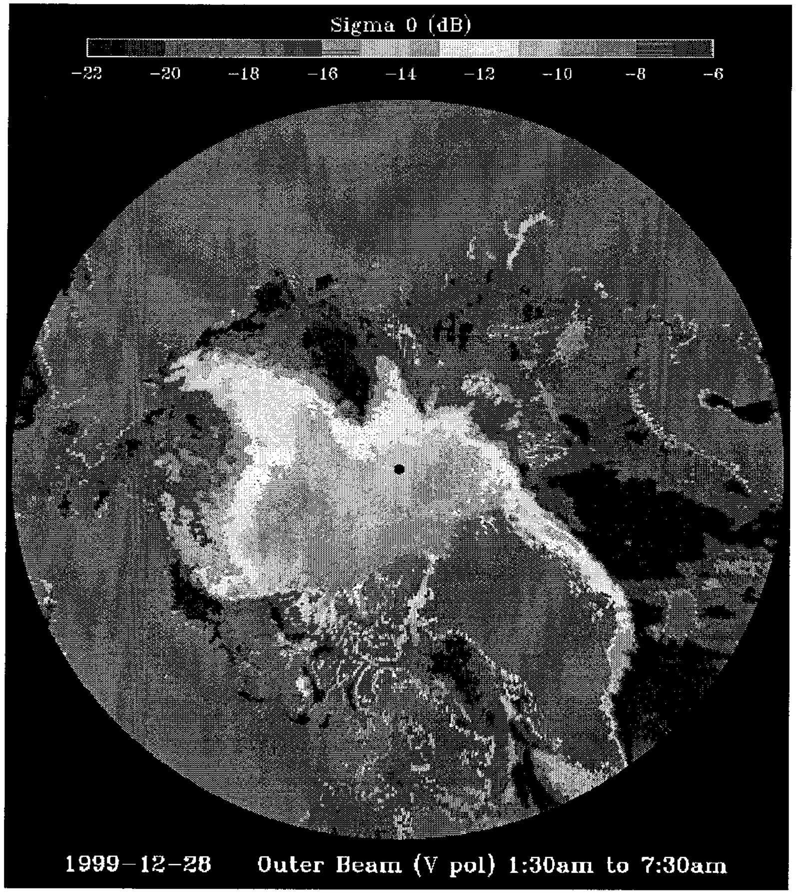
Monitoring Tropical Cyclone with High Resolution Wind Field

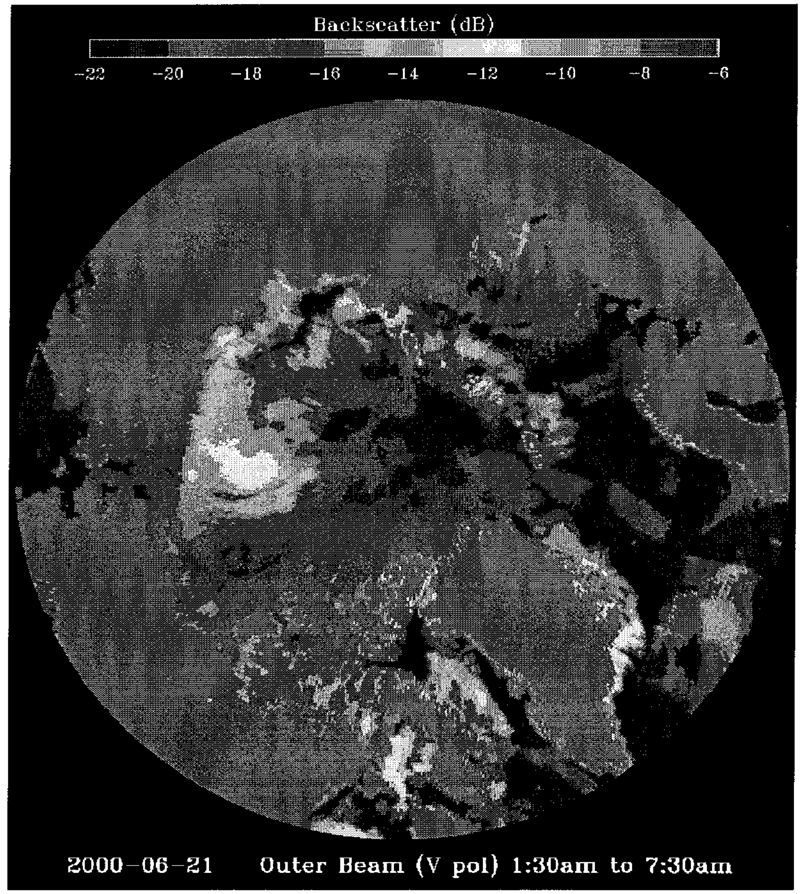
Synoptic view of hurricane Floyd
13 September 1999



- Early detection of storms (thru closure of cyclone)
- Synoptic view of hurricanes (eye, eye wall, high wind boundary, fine structure)
- Improving hurricane track prediction (ship deployment & ship routing)

Arctic Sea Ice Mapping and Monitoring





Winter perennial ice has high backscatter and appears as yellow to red in the above image of the Arctic on 12/28/2000.

During summer transition, sea ice surface melting caused the decrease in backscatter and ice albedo (image on 6/21/2000).